SYMBOLIC LOGIC (HS30068)

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IIT KHARAGPUR

Module 2

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Topics

- What Informal Logic is
- What critical thinking is
- What a Claim is
- What an argument is
- Basic components of argument
- Characteristics of an argument
- Kinds of arguments
- Different Criteria for different kinds of arguments

Key Terms:

- **Critical Thinking**
- **Claim**
- **Argument**
- **Premise**
- **Conclusion**

INFORMAL LOGIC: The LOGIC for REASONING in ordinary, real life situations.

If you ask: WHAT IS LOGIC?

The answer from INFORMAL LOGIC is that Logic is:

- A systematic study of reasoning, or of inferences expressed in everyday language
- A tool for reasoning well in real life situations
- A tool for promoting critical thinking

Logic: An art and science of reasoning (a branch of Philosophy) that teaches us to understand and evaluate reasoning, to prove or demonstrate following certain rules, and also to *think critically*

Critical thinking:

Reflective thinking on *why* one has to accept a claim, or believe in something, or do something

►As opposed to blind, uncritical acceptance)

It is about being aware of the *reasons* or *grounds* before accepting a claim, and also on assessing the ability of these reasons to support the claim.

Critical thinking is needed:

►To justify (give reasons for) one's beliefs
►To evaluate justifications (reasons) given by the others before accepting a suggestion

Overall, intellectually a critical stance.

The central issue of critical thinking, thus, is whether or not to accept or reject a **claim** on the basis of the reasons provided.

Claim: A statement that says something that is either true or false**.**

Example:

Bangkok is in Asia.
New Delhi is in Japan.

Claims are Declarative statements.

Non-claims: Statements about which cannot meaningfully be considered as true or false.

Example:
Be quiet! (commands)
What is your name? (questions) …

Types of Claims:

(a) Unsupported X

The unsupported claims are mere opinions. No room to apply critical thinking, because no reasons are provided with the claim.

(b) Supported (by reasons) ✓

This is what we are interested in. The display of reasoning or the logical ground is more evident.

Argument: A logical argument is a **set of claims.** But not all sets of claims are arguments.

A set of claims (statements, propositions) representing or recording a piece of reasoning.

Here, by argument: We do **NOT** mean verbal dispute, squabble.

We mean: A certain kind of reasoning process. For our purpose**,** an argument is::

► **Argument**: A **structured set of claims** with :

(a) A principal claim that is at issue, and

(b) Other claims that are offered as supporting reasons or evidentiary basis for the principal claim.

Structured: Certain kind of logical relationship between the reason(s) provided and the principal claim.

Components of an argument:

Conclusion: The principal claim in an argument that is argued for.

Premise(s): A claim / claims that is/are offered as the supporting evidence (evidentiary basis) for the conclusion in an argument.

Example 1*:* **We are in for a wet winter. Because, the Scripps Institute of Oceanography says so**.

Conclusion: We are in for a wet winter

Premise: The Scripps Institute of Oceanography says so

Example 2*:* Subatomic particles are invisible, so the material objects composed by them also must be invisible.

Conclusion: The material objects composed by them also must be invisible

Premise: Subatomic particles are invisible

Standard form of an argument: Separate the premise (s) and conclusion with a line, and use the triple dot to mark the conclusion.

Premise 1
Premise 2

$\therefore$ Conclusion

Triple dot

Alternative form:

{P1, P2…..} $\rightarrow$ Conclusion

Example: **We are in for a wet winter. Because, the Scripps Institute of Oceanography says so**.

In Standard form:
The Scripps Institute of Oceanography says so

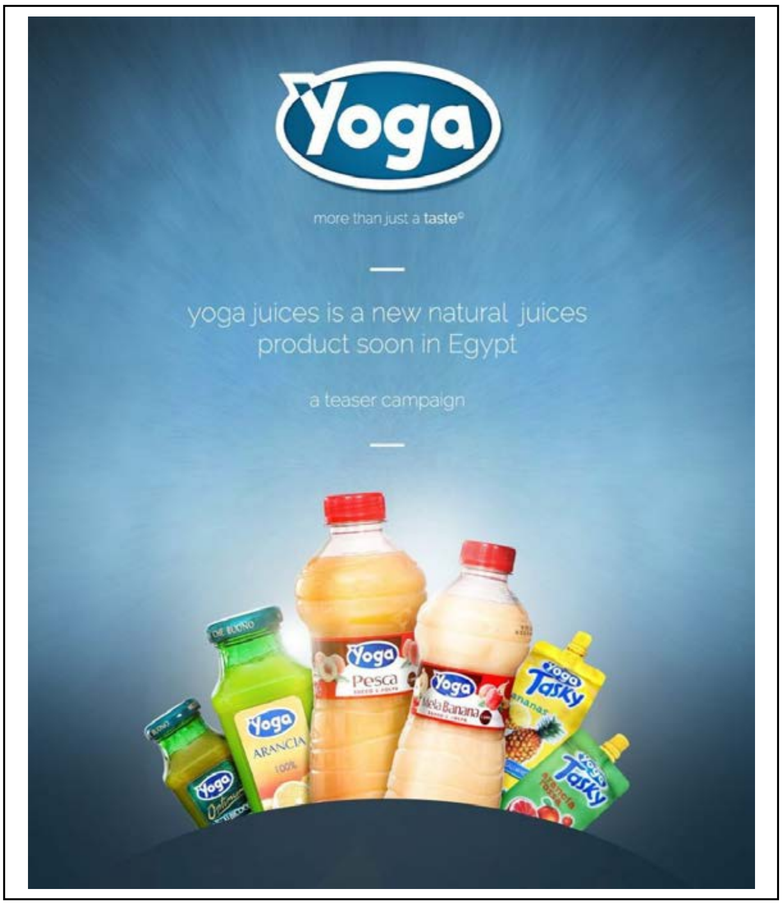
$\therefore$ **We are in for a wet winter**

Why do we use arguments? Several reasons:

- To persuade, to convince
- To prove a point, to establish a case, or to publicly demonstrate
- To express ourselves more cogently

Where do we use arguments?

- Legal arguments in court
- Academic publications
- Journal papers
- Report of scientific observation and experiments
- Advertisements
- Speeches
- Social conversations
- Newspaper articles, editorials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a teaser campaign

Arguments:

1. Number of premises may vary.

    (i) 1-PREMISE 1 CONCLUSION TYPES

    (ii) MULTIPLE PREMISE/ 1 CONCLUSION TYPES:

Example: All physical objects have mass.
This table is a physical object

∴ This table has mass.

2. Only one conclusion.

3. Though there is a standard form for arguments, in ordinary language, arguments may also come in non-standard form:

Example 1: We are in for a wet winter. Because, the Scripps Institute of Oceanography says so.

Problem: The sequence is wrong. In standard form, the premise(s) should come first.

Example 2: Although by definition the unconscious patient cannot tell you whether he perceives pain, available data suggests that he may; you can't know that he doesn't perceive pain.
[Issues in Law and Medicine, M.P. McQuillen, "Can People Who Are Unconscious Perceive Pain?"]

Problem: Sequence correct, but complexity level in the content is high. Hard to identify which is a premise, which one is conclusion.

In Standard Form, the argument is:

P1. By definition the unconscious patient cannot tell you whether he perceives pain

P2. (But) Available data suggests that he may

∴ Conclusion: You can't know that he doesn't

► This brings us to an important point: <u>Recognizing an argument</u>

- Read the set of claims carefully, and check if a logical relationship of premise-conclusion exists.
- Look out for linguistic clues:
  Premise-indicator words: E.g. Because, For, Given that…
  Conclusion indicator words:E.g. So, hence, Therefore,….

► How to tell if an argument is 'good' or 'bad'?

Some general criteria:

1.**Clarity** of the issue and the overall purpose: Clarity is desirable. **Issue**: Is the point made clearly in the argument? **Purpose**: Has it made its goal clear? Has it made its target audience clear? Ex: Is it making a Legal point or a scientific Point?

2.**Relevance of the premises**: Premises shd be *relevant* to the truth of the conclusion. Irrelevant premises undermine the value of the argument.

A premise is relevant if its acceptance makes a difference to the truth or falsity of the conclusion.

3. **Sufficiency of the premises**: Premises which are insufficient to establish the conclusion affect the acceptability of the argument. Desirable to have premises sufficient **in number**, **in kind**, **in weight or importance.**

4.**Value of the conclusion**: **Novelty** of the conclusion adds value, **importance** or **significance** of the conclusion matter.

5.**Resilience of the argument**: Ability to meet possible rebuttal. How well can the argument meet reasonable and obvious objections?

These are general criteria. Criteria of goodness and badness of arguments differ according to the category / kind of arguments.

Kinds of arguments:

3 basic kinds

1. **Deductive**
2. **Inductive**

And

3. **Abductive**

Accordingly, the logic differs: Deductive logic, Inductive Logic, and Logic of Abduction.

Deductive arguments:

This a type of arguments, such that their premises are supposed to provide **conclusive support** to the conclusion.

The conclusion is supposed to be **“contained”** in the premises, such that we should be able to derive the conclusion from a logical analysis of the premises. **The conclusion is not something out of the premise-base.**

Conclusive support: No room for doubt or uncertainty. The truth of the conclusion is supposed to be completely guaranteed by the truth of the premises.

When the premises of a deductive argument can completely guarantee the truth of the conclusion, the deductive argument will be considered as **'good'**.

When the premises of a deductive argument fail to do that, the deductive argument will be considered as **'bad'.**

Example :

1. All Physical objects have mass.
2. This table is a physical object.

Therefore, this table has mass.

Note: It is an argument. And it is a deductive argument. The conclusion is contained in the premises.

Note: The conclusive support that the premises together provide to the conclusion.

Therefore, it is a 'good' deductive argument

Inductive arguments:

This is a kind of arguments which by nature are such that

(a) Their premises are not expected to provide absolute certainty. They can provide **partial, probabilistic support** to the conclusion.

(b) The conclusion is **not** “contained” within the premises. It is supposed to be always outside the premise base. A new addition beyond what is known.

(c) From premises to the conclusion, there is always a jump : **INDUCTIVE LEAP.** A lep from the known to the unknown, from the observed to the unobserved.

(d) The conclusion is probabilistic. Not aimed to deliver certainty. ► Even the best of the Inductive argument can only provide partial, probabilistic support to the conclusion.

Example of an inductive argument:

1. Observation on Day 1: $Crow_1$ is black.

2. Observation on Day 2: $Crow_2$ is black.

....

n. Observation on Day n: $Crow_n$ is black

Premises

Conclusion: Therefore, Crown+1 will be black

Or, Therefore, all crows are black.

► Note: In the Inductive argument, the conclusion is NOT contained in the premises.

►And the premises can at best provide probabilistic support. Their goal is not absolute guarantee the truth of the conclusion.

►Inductive arguments are NOT ‘bad’ deductive arguments. They are of a different type.

The two types are different, and they are to be treated differently with different sets of criteria.

In Deduction, the pattern is from premise, the conclusion is an analysis of the premise.

Example: 1. This flower is pink and fragrant.

Conclusion: This flower is pink.

In Induction (this is not Mathematical induction), the pattern is from a set of observations, to a new observation:

►(i)Next crow that I shall see will also be black.

Or, to an inductive generalization:

(ii) Some observed crows are black

►Therefore, all crows, even the unobserved ones, will be black.

Generalization: A universalization, or abstraction, of a claim.

Inductive generalizations can be of different types:

A. **<u>Statistical generalization</u>**: Generalization based on statistically representative samples. When sample size is large and samples are random, and we find 80% of them have a property A.

Generalization: ►Most or all of them have property A.

<u>B. **Predictive induction**</u>: From observed past samples, generalization about future sample (s).

E.g. Black clouds brought rain in the past.

►So, this black cloud is likely to bring rain.

Or, generalization: Black clouds will bring rain.

<u>C. **Enumerative induction,**</u> **or** **<u>induction by Simple Enumeration</u>, or** **<u>Simple Induction</u>**: Generalization based on random samples.

<u>Form:</u>

Some As are B

Therefore, All As are B.(Strong claim)

Or, **The next A will be B** (Weak claim)

Enumerative Induction is very common. not always bad: ‘Green plants need sunlight’ is a generalization based on number of observations. ‘Adding turmeric makes food yellow’ is a generalization based on observations.

But it is problematic. One counter-example can undermine it. Counter-example: Example to the contrary. Example that disproves a belief or a statement.

(i) When sample size is small: Saw 2 snakes, and both were poisonous. So, **all snakes are poisonous.**◄

(ii) or is unrepresentative: The few mangoes tasted were sour. So, **Mangoes are sour fruits.**

(iii) Or, when the highly improbable, and rare sample is overlooked.

► The realization that “Not all swans are white”.

The western countries (mostly Europeans) used to believe that: All swans are white.

Because that is what they observed in their own countries.

Then, in 1697, the Dutch explorer Willem de Vlaminge discovered **black swans** in Australia.

It was a shock and a blow to the belief: All swans are white.

Black swan: Now a metaphor for the fallacy of placing too much faith in a strong inductive generalization. A highly improbable but real counterexample can undo it.

► Deductive and inductive arguments are different, but not mutually exclusive.

- The same conclusion may follow from a deductive and an inductive argument.

Example: Conclusion: The sun will rise tomorrow

<u>By Deductive argument:</u>

1. Given the earth's orbital motion
2. Given the earth's rotation on its own axis
3. Given the sun's position vis-à-vis the earth

---

4. Therefore, after 24 hours from a position on earth, tomorrow the sun will appear to rise.

<u>By Inductive argument:</u>

1.For years, sun has been seen to rise in the morning, [**inductive base**]

Therefore, the sun will rise tomorrow

Abduction

Abduction is also known as **Inference to the Best Explanation**.

It is a form of argument that selects a hypothesis that **best explains** an observed fact/event/state.

Steps:

►It starts from the observed fact **D**.

►Looks at the probable explanations: The competing hypotheses as alternative explanation of the fact

►Selects the **best explanation** **H** among them

Concludes: Therefore, H is likely to be the best explanation for D.

Schematic form:

►*D* is a collection of data (facts, observations, given) to be explained
►There are many hypotheses that explain *D*, i.e. they would explain D, if they are true
►**No other hypothesis explains *D* as well as *H* does.**

Therefore, *H* is inferred to be best explanation of *D*.

- Abductive reasoning is often used in sciences
- Abductive argument starts from the event / fact / effect to its pre-condition /cause.
- Its nature is probabilistic. But its pattern is different from Inductive. Typically used under uncertainty in a context.

Ordinary example:

Start: ► D = Observed pool of water in the corridor

►**Why D?** Look for explanations

►Several competing hypotheses to explain

►Suppose H= ‘leakage on the roof’ is found to be the **‘best’. No other hypothesis explains it as well.**

Therefore, H is inferred to be the best explanation for D.

Scientific example:

► D = Observed fact of extinction of the dinosaurs
Which is the best explanation? (Abductive reasoning)
Meteor strike is the hitherto ‘best explanation’.

► 2nd example from Palaeontology a perplexing problem:

D= **Cambrian explosion**: Unparallel emergence of organisms in the rock fossils, nearly all the animal phyla in existence today are present. Between 542-530 Million years ago, a sudden appearance of a huge number of different kinds of microfossils.

Darwin considered it as the singlemost serious objection to his theory of evolution by natural selection. [*Darwin's Doubt*, (Stephen C. Meyer, New York: HarperOne, 2013)].

Competing hypotheses.

►Each H is a probable explanation

Out of these: In abductive reasoning, one is chosen as the **'best'** explanation under the circumstances: <u>Inference</u> to the 'best explanation'.

This inference is based on an <u>elimination process</u>: **Elimination or rejection of the other rival hypotheses**.

Elimination requires extensive research for evidentiary support, verification, explanatory adequacy etc.

Various parameters.

The **strength** of an abductive conclusion depends on several factors, such as:

1. How good H is by itself, independently of considering the alternative hypotheses,
2. How thorough the search was made for alternative explanations
3. How decisively H surpasses the other alternatives: To establish it is the **best**
4. Many pragmatic considerations, including

   4.1. What are the costs of being wrong and the benefits of being right,
   4.2. Implications for the rest of the body of knowledge
   4.3. How strong the immediate need is to come to a conclusion at all.

So, the criteria for ‘good or ‘bad’ abductive arguments: Is it **strong**? Then it is good. Is it **weak**? Then it is bad.

Strength and weakness depend on many factors as shown above.

The criteria of ‘good’ and ‘bad arguments for deductive and inductive arguments are very different.

For determining whether <u>Deductive arguments</u> are ‘good’ or ‘bad’, the major criteria are:

- **Validity / Invalidity**
- **Soundness / Unsoundness**

For **<u>Inductive arguments</u>**:

- <u>Good</u> inductive argument: **Probabilistically strong**
- <u>Bad</u> inductive argument: **Probabilistically weak**

<u>Validity and Invalidity:</u>

A ‘good’ deductive argument: A Valid deductive argument

A ‘bad’ deductive argument: An Invalid deductive argument

Deductive arguments: Validity and Invalidity

1. Valid: (a) Does the truth of its premises conclusively establish the truth of its conclusion? YES

(b) Does the truth of the conclusion "follow" from the truth of the premises? YES

2. Invalid: (a) Is it possible for the conclusion to be false even when the premises are all true? YES

(b) Does the truth of the conclusion "follow" from the truth of the premises? NO

Definitions

Validity:

A deductive argument is **valid** if and only if it is **not POSSIBLE** for the premises to be true and the conclusion to be false. The conclusion is '**entailed**' by the premises. A relation of logical necessity

Invalidity:

A deductive argument is **invalid** if and only if it is **POSSIBLE** for the premises to be true and the conclusion to be false.

Example:

1. All Physical objects have mass.
2. This table is a physical object.

Therefore, this table has mass.

The conclusion **‘follows’** from the premises.

If the premises are true, it is **impossible** for the conclusion to be false. In other words, the conclusion <u>**must**</u> be true: **VALID**

Example:

1. A is taller than B.
2. C is taller than B.

Therefore, A and C are same in height.

The Conclusion **does not ‘follow’** from the premises.

Even if we assume the premises to be true, it is <u>**possible**</u> for the conclusion to be false. It is <u>not necessary</u> that the conclusion must be true: **INVALID**

Note:

The definition of validity is good, but it is somewhat loose. It does not safeguard the 'goodness' of deductive arguments.

For, **it allows many spurious deductive arguments also as valid**.

Consider:

For a valid argument, if premises are all true, conclusion must be true.

For an invalid argument, even if premises are all true, conclusion may be false.

But what happens when premises are NOT all true? What if one or more of the premises are false?

Example:

P1. A triangle has three angles. T

P2. The sum of three angles of a triangle is 190 degrees. F

C: Therefore, if one angle of a triangle is 90 degrees, the two other angles must add upto 100 degrees.

<u>VALID</u>

The conclusion **'follows'** from the premises in a certain sense. ***If*** we assume the premises to be true, the conclusion validly 'follows'. So, argument is valid.

A strange result: False premises do NOT ensure invalidity.

Arguments that are of no worth, pass the criterion of validity**.**

So, validity is not enough to ensure the 'goodness' of a deductive argument.

We need a stricter criterion. And that is **soundness**.

Soundness:

A sound deductive argument must fulfill both of the following conditions:

1. It must be valid
2. Its premises must be true.

Validity + True premises.

This rules out the 'false premises' cases. They may be valid, but NOT sound.

Note:

- **All invalid arguments are unsound**
- **Valid arguments with false premises are unsound.**

Value of validity: It ensures that if we begin with truth, we are not led from truth to falsity.

Value of soundness: It ensures the our beginning is in truth.

Consistency:

An additional requirement: In a ‘good’ argument, the premises should be, not just true, but true in an internally consistent manner.

Logical Consistency: It is a property of a set of statements / set of beliefs. {p, q, r……}

A set of statements is logically consistent if and only if (*iff*) the members of the set are:

(i) True together

(ii) Simultaneously true: true at the same time

(iii) Their truth is mutually compatible, i.e. if it is not the case that the truth of the one cancels / contradicts the truth of the other.

The set is **consistent** *iff* there is at least one case, i.e. *iff* it is **possible** for all the members to be true together.

The set is **inconsistent** *iff* it is **impossible**, i.e., there is not even one situation for them all to be true.

Consider set **Γ:** {a,b,c,........., n}, where a,b,c…are different statements.

Suppose **at T_1**: The members of Γ are: {T, F, T,........, T}

Is Γ consistent? Or Inconsistent?

Now consider **Γ at T_2**: The members are {a,b,c,......,n}: {T,T,T,.....,T}

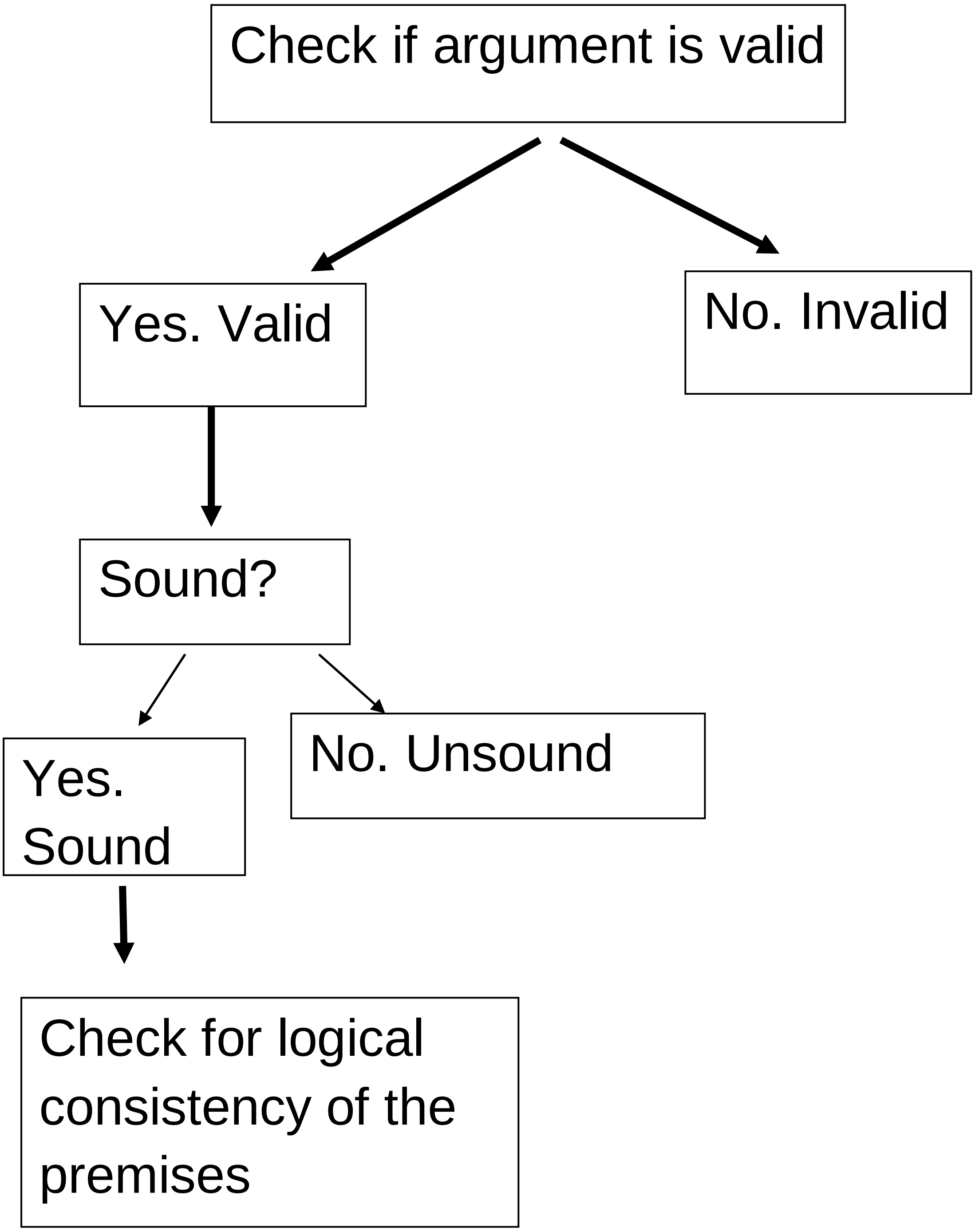
► The situation at T_2 is sufficient to establish Γ as **consistent set**

Now consider another set **Γ'**: {a,b,c,.......not-b, n}

►There is **no possibility** of every member of this set to be true at the same time. Truth of b entails falsity of not-b, and vice versa.

► The set Γ' is **inconsistent.**

So, for deductive arguments:



For inductive arguments: Probabilistic Logic, Bayesian Nets.

Bayes Nets (briefly)

• Bayes nets are directed acyclic graphs (DAGs) where each node represents a random variable

• The intuitive meaning of an arrow from a parent to a child is that the parent directly influences the child

• These influences are quantified by <u>conditional probabilities</u>

Suppose a doctor sees a patient with chronic cough and respiratorial problems.